PROF. ERNST ABBE.

FORTY YEARS' PROGRESS, 1866–1905.

ERNST ABBE, born January 23, 1840, was the son of a foreman in a spinning mill at Eisenach. He was a student at Jena and Göttingen, graduating at the latter university with a thesis on the mechanical equivalent of heat. After teaching for some time at Frankfort-on-Main, he established himself at Jena in 1863 as a privat docent in mathematics, physics, and astronomy, taking for a special subject of instruction the theory of errors. In 1870 he was appointed an extraordinary professor. In 1874 there was a proposal to establish a physical laboratory at Jena, and Abbe was offered the professorship of physics, but his connection with Carl Zeiss had then begun, and he was compelled to decline the offer. He had married in 1871 the daughter of Prof. Snell, and has left two daughters.

Carl Zeiss had established himself at Jena in 1846 as a manufacturer of optical instruments; for some years the business prospered, his microscopes were as good as those of other makers, probably neither better nor worse; but Zeiss was not satisfied; he felt that the microscope ought to be improved, and in endeavouring to effect improvement he realised the deficiency of his own equipment; after one other unsuccessful attempt he enlisted Abbe's help in his work.

The partnership which has had so remarkable an effect on the manufacture of optical instruments began in 1866. Abbe's task was a hard one; the theory of the microscope was at that date only partially understood; the corrections to the lenses were made by a rough trial and error method, and the results were doubtful; the first step was to solve a mathematical problem of no small difficulty, and trace the path of the light through the complex lenses of a microscope objective.

Abbe soon found out the defects of the ordinary theory, and was led in 1870 to what is now known as the Abbe theory of microscopic vision; unfortunately, no complete account of that theory from his own pen has yet been printed, though the "Collected Papers of Ernst Abbe," of which the first volume was published last year under the skilful editorship of Dr. Czapski, and noticed in these pages recently (NATURE, vol. lxix. p. 497), go far to fill the gap, and it is to be hoped that Dr. Czapski himself or some other member of the Jena staff will now be in a position to give the complete theory to the world. It is not necessary here to discuss the controversy which has arisen over the matter, due in great measure to an incomplete representation of the problem and to a misconception of the theory.

It is clear that if we can treat the object as self-luminous, or if we know the distribution of light with respect to both intensity and phase over the object plane, then we may start from the object as our source, and the principles of the wave-theory, as Lord Rayleigh has shown, will allow us to determine the distribution in the view plane. If, however, the distribution in the object plane is unknown, we must go back to the source, consider how the light from the source is modified both by the object and the lenses, and from this infer what the resulting image will be like.

Diffraction patterns will be formed practically in the second focal plane of the object glass, and the distribution of the light in the image can, theoretically at any rate, be deduced from a knowledge of the intensity and phase of the disturbance in these patterns.

This theory, at any rate, led Abbe to most valuable results, and was one source of the success of the Zeiss microscope. From it, among other consequences, he deduced the importance of what is now known as the numerical aperture, the quantity $\mu \sin \alpha$, where μ is the refractive index of the first lens of the object glass, and 2α is the angle which that lens subtends at the point where the axis of the system cuts the object plane.

But the assistance given by the new theory was not alone sufficient to solve the problem. It had long been known that when the best glasses then obtainable were combined to form an achromatic system, a secondary spectrum remained, and until this could be removed it was hopeless to look for perfection in the image.

The experiments of Stokes and Harcourt had been directed to the discovery of glasses free from this defect, and Abbe and Zeiss in their early days made many attempts in the same direction, using in some cases liquid lenses to secure the desired end.

In 1876 the South Kensington Loan Exhibition of Scientific Apparatus took place, and Abbe came over to inspect it. In his report, published in 1878, he writes:—"The future of the microscope as regards further improvement in its dioptric qualities seems to lie chiefly in the hands of the glass maker," and then he explains in what direction changes are required and how difficult it is to introduce them.

This report of Abbe's fell into the hands of Dr. Otto Schott, a glass maker of Witten, in Westphalia. Schott communicated with Abbe in 1881, and commenced his investigations into the subject. Next year he removed to Jena, and, aided by a large grant from the Prussian Minister of Education, the experiments were satisfactorily concluded, and the firm of Schott and Co. was established; in 1884 he was in a position to commence the wholesale production of optical glass. The combination was now complete. "To-day it is difficult," as Prof. Auerbach writes in his recent work on the Carl Zeiss Stiftung in Jena, "to think of the Optical Works without the Glass Works, or *vice versâ*."

From this time onwards Abbe's time was fully occupied in developing the new undertaking; the history of his life would be the history of the works, and in the Zeiss instruments, known throughout the world, his monument is to be found.

But in many ways the latter years of his life are not the least interesting. Carl Zeiss died in 1888; next year his son Roderick retired from business, and Abbe was left sole proprietor of the optical works. In 1891 he created a kind of trust known as the Carl Zeiss Stiftung, to which he ceded all his proprietary rights, both in the optical and also in the glass works.

The story of the Carl Zeiss Stiftung as told by Prof. Auerbach is a very striking one. The statutes, due to Abbe himself, which were confirmed by the Grand Duke of Saxony in 1896, and have the force of law, can up to 1906 be modified by a simple procedure; afterwards legal action is practically required to render a change valid.

The works are a great cooperative concern. "To provide a large number of people with the most favourable opportunities for labour is both the means and the end of the Stiftung. The individuals who benefit by it are at the same time those who maintain and increase it. The officials and workmen employed at the optical works, the community and the university contribute their share towards the increase of the value of the property, and these, therefore, are entitled to participate in the benefits." The university alone will shortly have received 100,000*l.* from the scheme.

The Stiftung is managed by the Stiftung Adminis-

tration; on this the Saxon Government appoints a representative or trustee whose duty it is to see that the statutes are obeyed; the works are supervised by boards of management appointed by the administration.

The employés possess the right of combination; they can be represented by their own committees, which may address the administration direct on any subject relating to the affairs of the concern. They are paid by piece-work, with a minimum time wage, and there is in the scheme a proviso by which no one, even though a member of the board of management, can receive a salary greater than ten times the average yearly earnings of workers of twenty-four years and over who have been at least three years with the firm. Moreover, when an employé has once received a certain wage and drawn it for one year his wage cannot be reduced because of slackness of trade. In addition to the wages calculated on the work done, every worker receives a share of the profits depending in any year on the net sum realised. There is also a liberal pension scheme, under which every employé who enters the works before his fortieth year is entitled, after five years' service, to a pension calculated at a rate which reaches 75 per cent. of his salary at the end of forty years' service, while the widows and orphans of employés have also pension rights. Finally, the working day is eight hours, and Abbe has put it on record in an address, delivered in 1901 to the Social Science Association, that in the case of 233 piece-workers about whom accurate statistics could be taken the total output was increased by 4 per cent. in the first year that followed the change from nine to eight hours.

Such has been Ernst Abbe's work; until 1903 he remained an active member of the board of management of the optical works; then he retired, partly on account of the state of his health, partly, if his health improved, to devote himself to his scientific work. The improvement hoped for never came, and he died last week, leaving it to the trained band of workers he had gathered round him to continue his task, and to show still further what can be done by the organised application of science to industry and manufactures. R. T. G.

M. PAUL HENRI.

ABOUT the year 1864, two brothers entered the meteorological department of the Paris Observatory, and for nearly forty years laboured with zeal and success to promote the best interests of that institution and of astronomical science generally. In the autumn of 1903, one brother, M. Prosper Henri, died suddenly on a holiday tour, and we now have the melancholy duty of chronicling the death of the second brother, M. Paul Henri. It is necessary to recall the close and intimate relations that existed between these two, because the scientific life of one was that of the other. No one has ever thought of them separately, no one has ever attempted to discriminate between their successes and their triumphs. The same day (November 8, 1889) they were both elected associates of the Royal Astronomical Society, and other instances of similar recognition of their united work might be quoted. We may quote the words of the late M. Callandreau of these two:—"si unis que nous ne voyons souvent en eux qu' une seule personne pour ainsi dire, si oublieux de faire ressortir leur mérites respectifs qu' il est difficile de distinguer ce qui peut appartenir a chacun dans l'œuvre commune."

It is an oft-told tale to recall how these brothers, with whom mechanical art was a conspicuous gift, constructed their own instruments, and laboured to complete the ecliptic charts on which Chacornac had worked, how their systematic work and diligence added to the number of small planets, and how, finally, the necessity was forced upon them of adopting improved methods in registering the places of stars in the crowded regions of the heavens. The history of the "International Chart of the Heavens," which has taxed the resources of so many observatories, was the outcome of their skill and resource. Not only did they provide the optical parts of the instruments that were employed in many observatories, but they laboured zealously on the zone allotted to the Paris Observatory, and it is believed brought their share to a successful issue. They led the way in the photographic examination of clusters like the Pleiades, and showed to others how unsuspected nebulæ might be detected.

A new era of activity opened for astronomy in the general application of photography, and few have contributed more to the harvest of results that has followed that activity than have the brothers Henri. They not only supplied the instruments with which the negatives were taken, but they suggested devices for the construction of measuring machines by which these negatives could be discussed. The reputation of one and both rests on their photographic work. Smaller work, such as the careful and accurate delineation of planetary markings, the observation of minute satellites, and the more ordinary routine of observatory work, are all forgotten in the large share taken in the application of photography to celestial measurement. His colleagues in the observatory spoke of the many excellent qualities that distinguished M. Prosper Henri as a colleague and friend, and one is sure that no less kindly expressions will be used towards M. Paul Henri, who has enjoyed the confidence and respect of all the directors of the Paris Observatory who have followed M. Le Verrier.

W. E. P.

NOTES.

THE cross of officer of the Legion of Honour has been conferred, *La Nature* states, upon Dr. Otto Nordenskjöld for his South Polar explorations. Mrs. Bullock Workman has been appointed Officier de l'Instruction publique for her travels in the Himalayas.

THE autumn meeting of the Iron and Steel Institute is to be held this year in Sheffield for the first time. Mr. R. A. Hadfield has been elected to succeed Mr. Andrew Carnegie as president of the institute. The visit will take place during the week beginning September 25. The most influential members of the Sheffield steel industry have associated themselves with the invitation to the institute, and a committee has been formed, of which the Lord Mayor of Sheffield and the Master Cutler are chairman and vice-chairman respectively. Colonel H. Hughes, C.M.G., has been appointed chairman of the reception committee, with Mr. J. Rossiter Hoyle as honorary secretary. Mr. Frank Huntsman—who is, we learn from the *Times*, a descendant of the Huntsman who founded the Sheffield industry of melting steel in pots about 170 years ago—will act as honorary treasurer, and Mr. John Wortley as honorary assistant secretary.

ON Thursday next, February 2, Prof. W. Schlich will deliver the first of a course of two lectures at the Royal Institution on "Forestry in the British Empire." The discourse on Friday, February 3, will be delivered by Prof. T. Clifford Allbutt on "Blood Pressure in Man."